

The University of Chicago

THE PROJECTION OF THE LATERAL
GENICULATE BODY ON THE CERE-
BRAL CORTEX OF THE OPOSSUM,
DIDELPHIS VIRGINIANA

A DISSERTATION SUBMITTED TO THE
FACULTY OF THE DIVISION OF THE BIO-
LOGICAL SCIENCES IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF ANATOMY
1934

By
DAVID BODIAN

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THE PROJECTION OF THE LATERAL GENICULATE BODY ON THE CEREBRAL CORTEX OF THE OPOSSUM, DIDELPHIS VIRGINIANA

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FIFTEEN FIGURES

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Considerable evidence has been accumulated during relatively recent years which demonstrates rather conclusively that the lateral geniculate body forms the principal, and probably the only, gateway for visual impulses passing to the cerebral cortex, and that the striate area of Elliot Smith (field 17 of Brodmann) constitutes the principal, and perhaps the only, part of the cerebral cortex which receives the terminals of nerve fibers arising in the lateral geniculate body. These conclusions have been reached mainly because experimentally produced lesions in the striate area, and in no other part of the cortex, of rabbits (Monakow, 1881, 1883-1885; and the Putnams, '26), dogs and cats (Monakow, 1889; Minkowski, '11, '13), rats (Lashley, '34 a) and monkeys (Brouwer et al., '28; Heuven, '29; and Poliak, '32, '33) result in definite and consistently localized foci of degeneration in the ipsilateral dorsal nucleus of the lateral geniculate body, and in no other subcortical centers. The position of these foci of degeneration

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I also wish to acknowledge my indebtedness to Profs. C. Judson Herrick, G. W. Bartelmez, and N. L. Hoerr, for their generous advice and encouragement during the course of this work. The drawings were prepared by Miss A. Nixon and the photographs by Doctor Bartelmez.

in the lateral geniculate body has further been shown to be dependent upon the position of the lesion in the striate area.

Although disagreement still exists as to the physiological interpretation of a localized visual projection, such as that described above, and as to the preciseness of such a localization in the animals mentioned, there can no longer be any doubt regarding the existence of an anatomically localized projection of the lateral geniculate body on the striate area of mammals. The numerous interesting and significant studies on these and related problems, have given rise to an extensive literature which has been reviewed adequately elsewhere (Minkowski, '13, '14; Henschen, '23; Poliak, '32, '33).

The purpose of the present investigation has been to determine whether there exists in the opossum, a generalized and lowly mammal, an anatomically localized geniculo-cortical projection, such as has been described in rodents, carnivores, and primates, and, if such a projection does exist, to determine its character—the arrangement of its subdivisions and the sharpness of their boundaries in both the striate area and the lateral geniculate body. Such a study has been considered desirable, since it would be of considerable interest to know whether in one of the most primitive mammalian brains the organization of the central visual system is comparable with that found in more highly developed brains, and whether the extent of that organization throws any further light upon the problem of the evolution of cortical localization. A program of investigation of the opossum brain, which has been in progress in this laboratory for more than a decade, has made this study possible, since descriptions of the forebrain (Loo, '30, '31), optic centers (Tsai, '25), thalamus (Chu, '32), and cortical areas (Gray, '24) of the normal opossum brain are now available. In this connection it might be mentioned that within recent years, several interesting accounts of experimental explorations of the cerebral cortex of the opossum have appeared, by Gray and Turner ('24), Rogers ('24), Weed and Langworthy ('25), and Langworthy ('27).

MATERIAL AND METHODS

Adult and apparently healthy opossums of both sexes were operated upon with aseptic technique, after anesthesia with morphine and ether. The skull was opened in the angle between the sagittal crest and the lambdoidal ridge by means of a trephine measuring 9 mm. in diameter, the dura incised and retracted, and lesions then made in the striate area with a von Graefe's knife. The smallest lesions were made by passing the knife, or a needle, through the unopened dural sheath, the latter being quite delicate and somewhat transparent. The animals were killed 5 to 6 weeks later (except case 1, which was killed 9 weeks later) with illuminating gas and the heads were perfused with 100 cc. of normal salt solution followed by 500 cc. of 80 per cent alcohol. The brains were then removed and placed in commercial 95 per cent alcohol for 3 weeks, frequent changes being made. This fixation was followed by paraffin embedding and sectioning of the paraffin blocks into ribbons 20 μ thick. Complete serial sections through the striate area and lateral geniculate body were stained in a 0.1 per cent aqueous solution of toluidin blue. Twenty brains were prepared in this manner, of which twelve have been selected for description. These were well stained and uncomplicated by infections, adhesions, or excessive spread of the lesions due to vascular damage. In addition, six brains were prepared by the Marchi method, after injury to the lateral geniculate body and thalamus, and two brains of animals with severed left optic nerves were prepared by the methods of Marchi, Nissl, and reduced silver. These will be described in a later communication.

It was found that paraffin sections of material fixed by prolonged treatment in alcohol, as described above, could be impregnated very satisfactorily with silver, using Rogers' ('31) modification of Bielschowsky's method. Protargol was used instead of silver nitrate (Bartelmez and Hoerr, '33). Every twelfth section of case 1 was treated in this manner, with results to be described below.

The figures used in the following pages to illustrate the position and size of lesions and foci of degeneration were prepared as follows: In the first seven figures, sketch A represents a dorsal projection of the right neopallium. The striate area is drawn in as mapped by Gray ('24), except that the portion which is turned in under at the posteromedial boundary of the hemisphere has been spread in the figure so as to appear to lie in the same horizontal plane as the rest of the area. The striate cortex which normally cannot be seen from the dorsal aspect is represented by the dotted outline. All lesions were made on the right side, except case 4, which has been transposed to conform with the other cases, and are shown in solid black as mapped under the microscope. Sketch C is a representative transverse section of the cerebral hemisphere through the lesion, indicated in solid black, in the plane shown in sketch A. The section through the hemisphere was drawn with the aid of the Edinger projector, and the lesion then drawn in with the aid of the microscope. Sketch B is a reconstruction of the dorsal nucleus of the right lateral geniculate body, seen as projected upon the sagittal plane, with the oral end directed toward the left and the dorsal side above. The foci of degeneration are represented by the hatched areas, except where the degenerated zone shows only slight or incomplete atrophy; such zones are indicated by stippling. Sketch D is a transverse section through the dorsal nucleus of the lateral geniculate body in a plane indicated in sketch B, and shows the transverse extent of the area of degeneration. This was drawn in the same manner as in sketch C. The medial border is at the left. The magnification of the cortical sketches is $\times 2\frac{1}{2}$; that of the sketches representing the lateral geniculate body is $\times 28$.

References to literature describing the topography and structure of the normal opossum brain have already been made above. The low-power photograph of the thalamus (fig. 11) further brings out the relations of the subcortical centers to be discussed.

DESCRIPTION OF MATERIAL

Case 1 (fig. 1)

Most of the right striate area has been destroyed, except for the anteromedial tip. The lesion extends forward into the peristriate area, a large portion of which has been damaged. The underlying alveus has been injured to some extent. All of the dorsal nucleus of the ipsilateral lateral geniculate body has degenerated, except for the posterior tip. The character of the degeneration will be described in detail below.

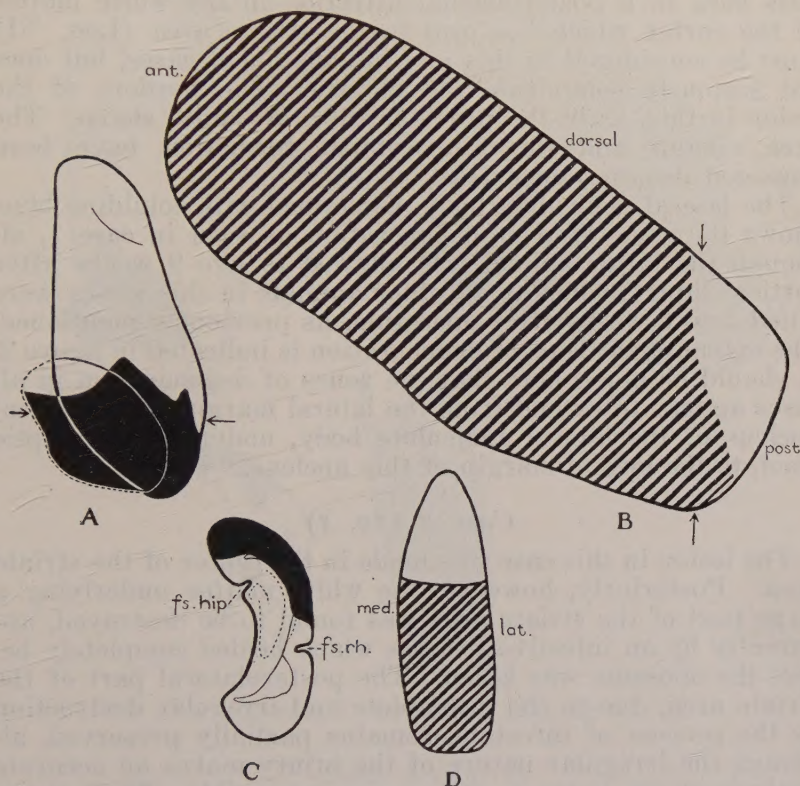


Fig. 1 A. Dorsal projection of right neopallium, showing extent of lesion in case 1. B. Projection on the sagittal plane of the dorsal nucleus of the right lateral geniculate body, showing the extent of the zone of degeneration in case 1. C. Section through the lesion in case 1, in plane indicated in A. D. Section through the dorsal nucleus in the plane indicated in B. *fs.hip.*, fissura hippocampi; *fs.rh.*, fissura rhinalis.

Case 2 (fig. 2)

The lesion in this case also involves most of the striate area, but in no place extends for more than 1 mm. into the adjoining peristriate area. A medial and a lateral portion of the striate area have been left undamaged, but these two intact areas should be considered as corresponding to smaller parts of the lateral geniculate body than might be apparent, since a large number of fibers passing from the lateral geniculate body to these areas have been severed by the lesion. The effect of the undercutting of geniculo-cortical fibers which pass back in a posteromedial direction in the white matter of the cortex which lies oral to the striate area (Loo, '31) must be considered in this and in subsequent cases, but does not seriously complicate the picture. The borders of the lesion in this, as in the previous case, are quite sharp. The area cinguli and the hippocampal formation have been damaged also, to some extent.

The lateral geniculate body, as stained with toluidine blue, shows the same kind of degeneration as seen in case 1, although the latter animal was allowed to live 9 weeks after cortical injury, whereas all other animals in this series were killed 5 to 6 weeks after operation, as previously mentioned. The extent of the zone of degeneration is indicated in figure 2. It should be noted here that the zones of degeneration in all cases appear to extend from the lateral margin of the dorsal nucleus of the lateral geniculate body, underlying the optic tract, to the medial margin of this nucleus.

Case 3 (fig. 3)

The lesion in this case was made in the center of the striate area. Posteriorly, however, the white matter underlying a large part of the striate area was found to be destroyed, apparently by an infective process which healed completely before the opossum was killed. The posterolateral part of the striate area, due to the incomplete and irregular destruction by the process of infection, remains partially preserved, although the irregular nature of the injury makes an accurate analysis of the lesion in this region impossible. The anteromedial part of the striate area is uninjured. A large part of the peristriate area has also been destroyed.

In the lateral geniculate body, three zones can be distinguished. A normal zone at the posterior tip is interpreted as the origin of the projection fibers which pass to the anteromedial intact portion of the striate area, as will be

evident from the other cases. An anterodorsal zone (stippled in fig. 3) which is irregularly and incompletely degenerated, corresponds probably to the irregularly damaged lateral portion of the striate area. The remainder of the dorsal nucleus of the lateral geniculate body is completely degenerated.



Fig. 2 Case 2. Orientation as in figure 1.

Case 4 (fig. 4)

Multiple lesions were produced in the striate area of this opossum. When the animal was killed, however, it was found that most of these lesions had fused, forming a relatively large, irregular lesion, surrounded by four very small lesions. The area of degeneration in the lateral geniculate body is very irregular and the atrophy is incomplete. The boundary

of the degenerated zone is not at all sharp, due perhaps in part to the irregular nature of the lesion in the striate area. No zones of degeneration in the lateral geniculate body could be found which might correspond to the small lesions in the area striata.

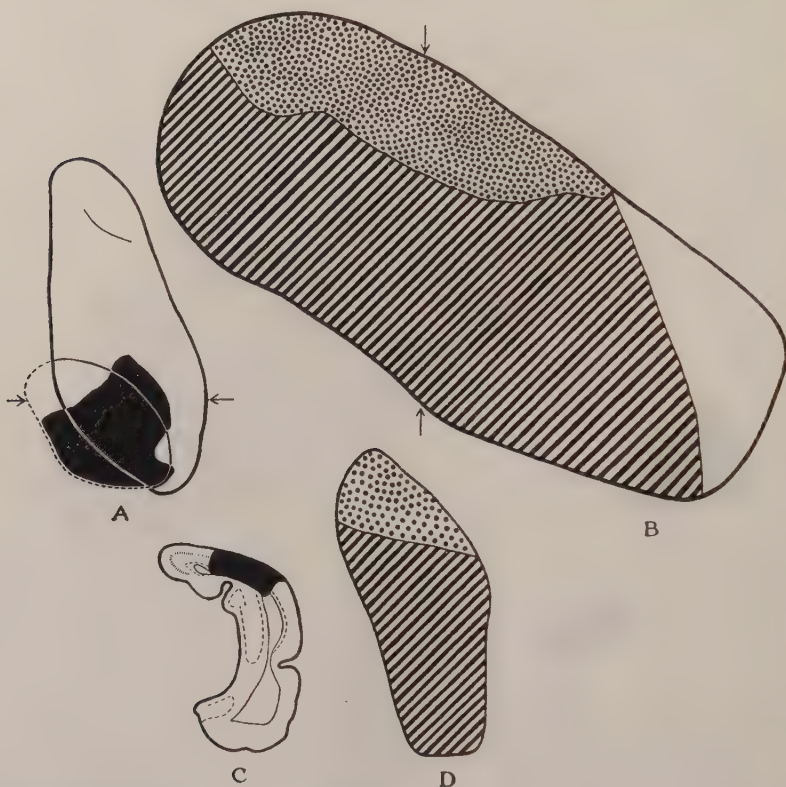


Fig. 3 Case 3. Orientation as in figure 1. The dotted areas indicate zones of partial degeneration.

Case 5 (fig. 5)

The lesion in this case has an irregular form, but the borders are quite sharp. The injury is limited to a small area on the dorsal convexity in the middle of the anterior part of the striate area, with slight involvement of the adjoining peristriate area. The degenerated zone in the lateral geniculate body shows marked atrophy in its central portion, and less complete atrophy in its periphery.

Case 6 (fig. 6)

This lesion is 1 mm. in its longest diameter, as measured with an ocular micrometer. Its greatest possible area is estimated as 1 sq.mm., or $\frac{1}{40}$ of the estimated extent of the entire striate area. The lesion has sharp borders and cuts to a

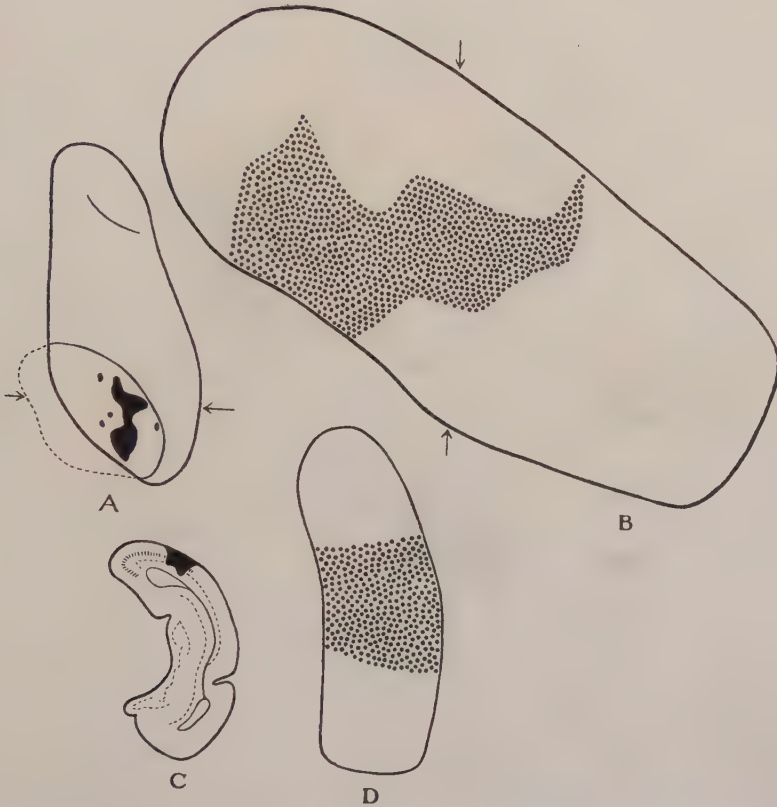


Fig. 4 Case 4. Orientation as in figure 1. The dotted areas indicate zones of partial degeneration.

slight extent the underlying optic radiation in the white matter of the cortex. The degenerated area in the lateral geniculate body is definite, and similar, as regards the character of the degeneration, to that in case 5.

Cases 7 and 8 (fig. 7)

An attempt was made in these cases, and in the following ones, to produce as small lesions as possible, since it appears probable, as Poliak ('33) has suggested, that definite information regarding the preciseness of localization in the optic projection can be obtained only by means of small, sharply defined

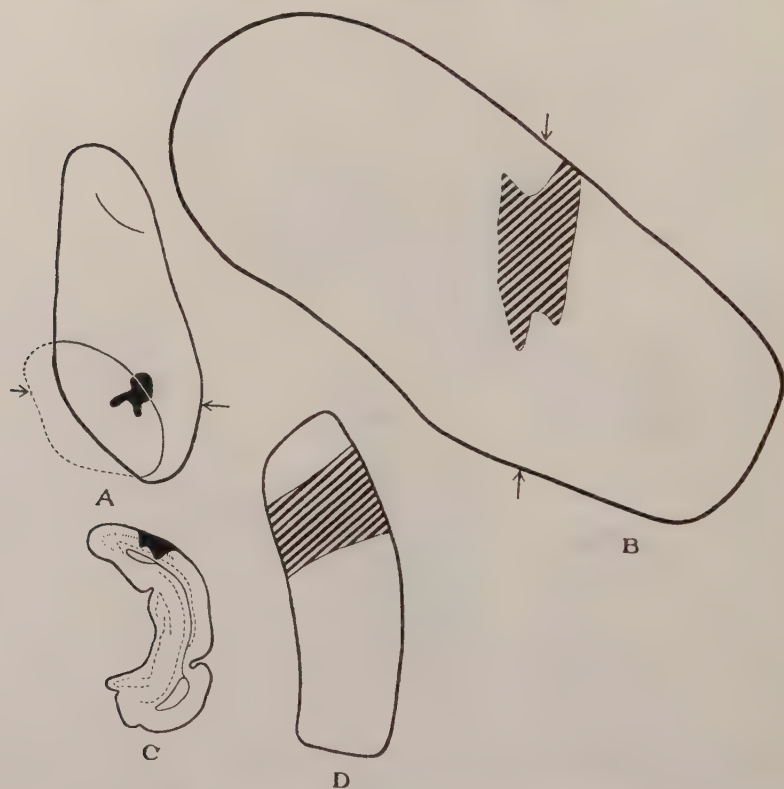


Fig. 5 Case 5. Orientation as in figure 1.

lesions. In cases 7 and 8 lesions were produced in the striate area which were estimated to have each an area of about 0.6 of a square millimeter. In case 7, the subjacent white matter is only slightly damaged; in case 8, the lesion does not affect the underlying white matter. The degeneration in the lateral geniculate body in these cases is very difficult to recognize with any great degree of certainty, being characterized merely

by a slight decrease in the number of nerve cells and a slight crowding of neuroglia cells. The positions of the lesions and of atrophied zones in these cases are indicated in figure 7.

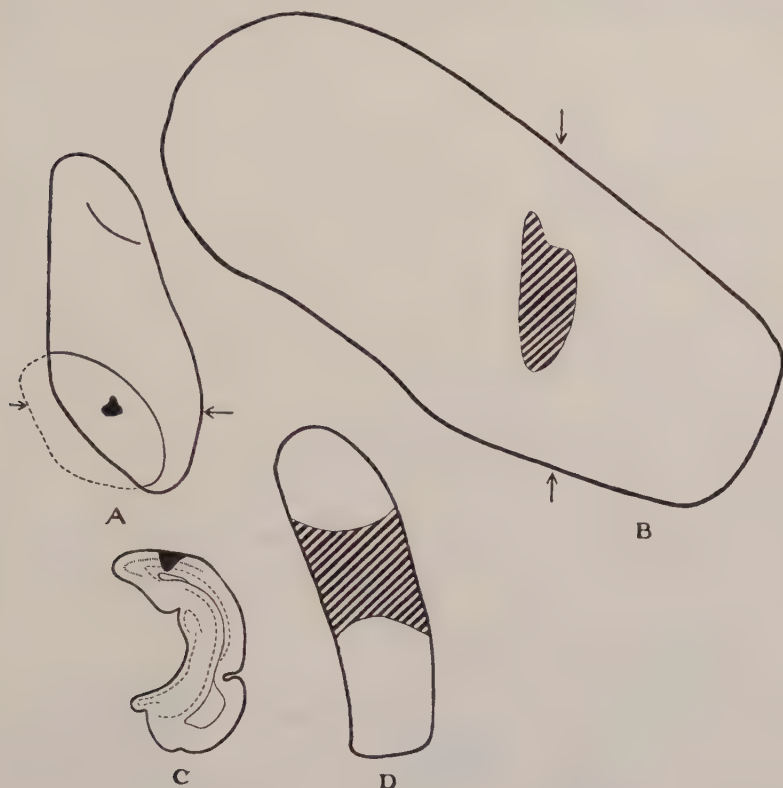


Fig. 6 Case 6. Orientation as in figure 1.

Cases 9, 10, 11 and 12

Lesions ranging in size from 0.4 to 0.03 of a square millimeter were produced in these four cases. All sections through the lateral geniculate body were carefully examined, but no recognizable changes could be found. Thus, the size of the smallest lesion in the striate area which produced cellular degeneration in the lateral geniculate body, recognizable with the method used, appears to lie between 0.6 and 1.0 sq.mm. If we assume that these minimal effective lesions are adequate indicators of the degree of preciseness of localization in the optic projection, and this is by no means certain, we may express the extent of that localization by saying that the unit

of the anatomical projection from the lateral geniculate body to the striate area of the opossum is represented by that fraction of the projection which passes to an area approximately $\frac{1}{60}$ to $\frac{1}{70}$ of the total area of the striate cortex. This offers a marked contrast to the situation obtaining in the

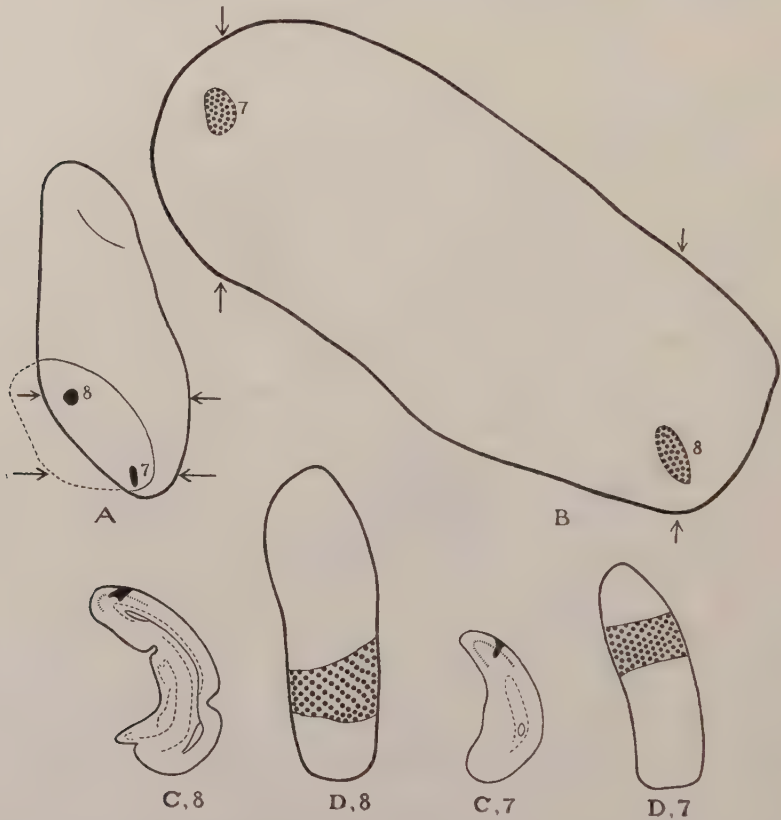


Fig. 7 Cases 7 and 8. Orientation as in figure 1. The dotted areas indicate zones of partial degeneration.

rhesus monkey, in which the corresponding unit of projection is approximately $\frac{1}{500}$ of the total area of the striate cortex, and perhaps smaller (Poliak, '33).

Figure 8 is a composite diagram, showing by means of distinctive outlines the areas of degeneration in the lateral geniculate body in the cases described, and the corresponding

lesions in the striate area. The areas of degeneration are duplicates of the ones shown in the preceding figures, but the sizes of the lesions in the striate area have been increased to include those areas which receive projection fibers that have

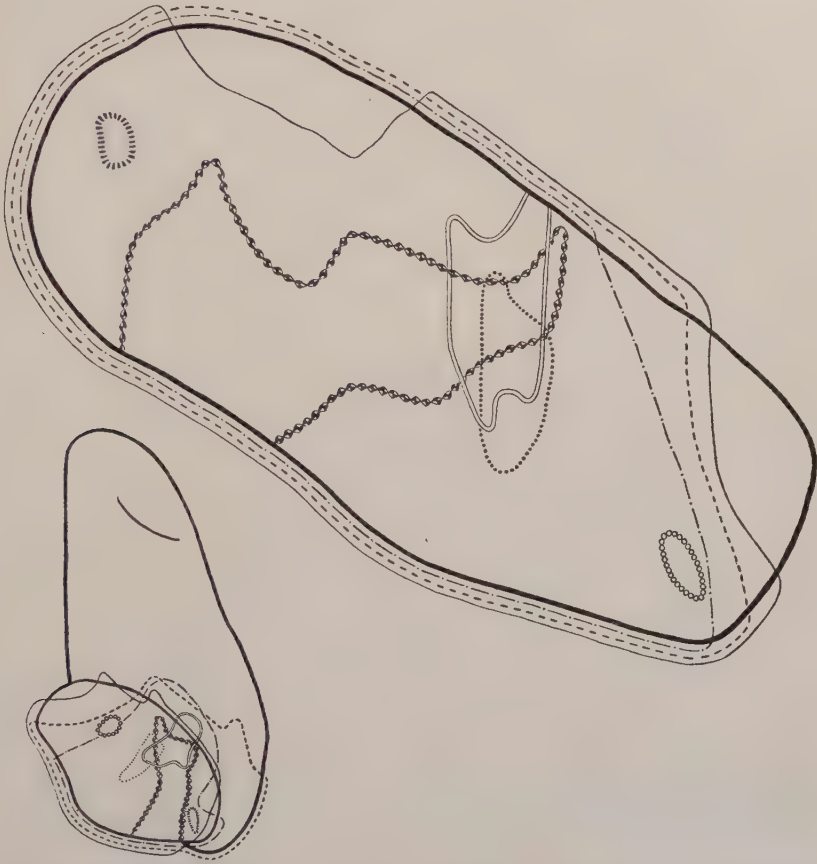


Fig. 8 Composite diagram showing lesions in cortex and zones of degeneration in dorsal nucleus of lateral geniculate body. Orientation as before.

been severed by the lesions. The added areas, of course, could only be estimated in a relatively rough manner. The orientation in this figure, as also in figures 9 and 10, is the same as in the preceding figures.

In figure 9 the projection has been mapped schematically to show nine arbitrary areas (indicated by the letters *a*, *b*, *c*, etc.) in the striate area, and the corresponding areas in the lateral geniculate body. The cases which were used to determine the corresponding zones are indicated by number in the zones shown in the lateral geniculate body. In cases

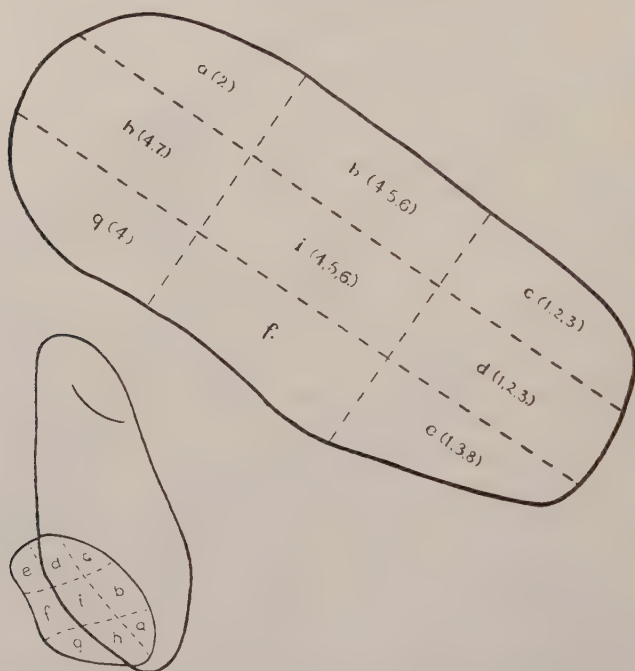


Fig. 9 Diagram showing nine arbitrary divisions of striate area and corresponding zones in the lateral geniculate body. Numbers indicate cases used to determine each zone.

1, 2 and 3 the spared portions of the lateral geniculate body and of the striate area have been used for mapping purposes, since they are smaller than the injured zones. It should be emphasized here that the nine areas do not represent the units of the visual projection, but merely indicate in a simple manner the pattern of the projection. Figure 10 probably shows more adequately the structure of the projection as a

whole, since the latter appears to be composed of elements which pass to contiguous zones of the striate area in the continuous manner indicated. The two planes of the projection are represented by an increase in size of dots along one axis and an increase in density of the dots along the other.

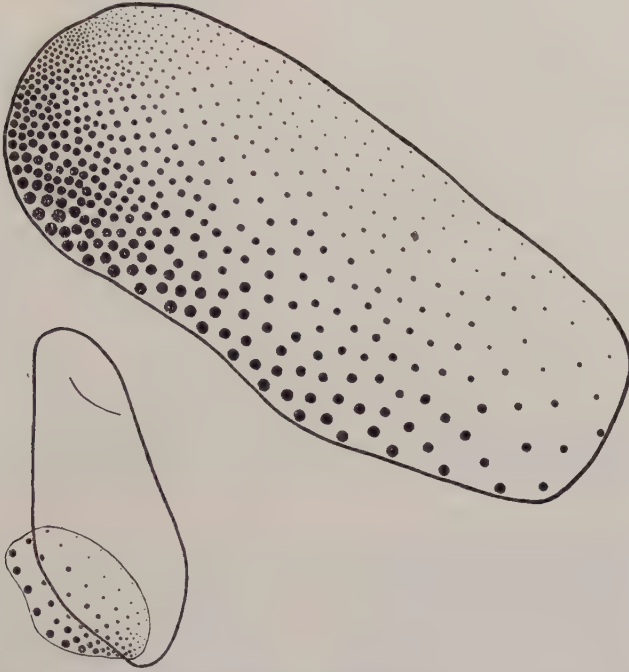


Fig.10 Schematic representation of orientation of the visual projection.

CHANGES IN OTHER SUBCORTICAL CENTERS

The contralateral lateral geniculate body, the ventral nucleus of the ipsilateral lateral geniculate body, the medial geniculate bodies, the superior colliculi, the pretectal nuclei, and the thalamic nuclei were examined in all cases for possible changes following injury to the striate and peristriate areas. No deviation from the normal could be detected in these centers, except in cases 1 and 3. In these cases (in Nissl material) definite loss of nerve cells and some proliferation of neuroglia cells could be recognized in the nucleus lateralis.

This nucleus has been described in the opossum by Chu ('32) and lies dorsomedial to the dorsal nucleus of the lateral geniculate body. In case 1 this degeneration of the nucleus lateralis was verified in the sections prepared by Rogers' method (fig. 11). In these sections, in addition to the loss of nerve cells, a distinct atrophy of fibers could be seen, but the degeneration of the neuropil was not as marked as that visible in the lateral geniculate body. Since these two cases differ from the others only in that a large part of the peristriate area, in addition to the striate area, has been destroyed, it is concluded that the peristriate area receives terminals of projection fibers which arise in the nucleus lateralis. Furthermore, there is no indication that the peristriate area receives terminals of fibers arising in the dorsal nucleus of the lateral geniculate body. The presence of such a projection is rendered dubious by the fact that in case 2, in which the striate area has been extensively damaged, but the peristriate area is practically uninjured, the lateral geniculate body appears as completely degenerated as the same nucleus in case 1, in which both the striate and peristriate areas have been severely injured. Minkowski has obtained similar results on the latter point in the cat ('13), as has Lashley in the rat ('34 a).

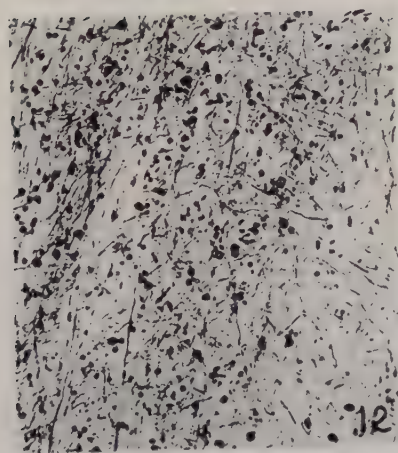
HISTOLOGICAL APPEARANCE OF DEGENERATED ZONES

The degenerated portions of the lateral geniculate body are characterized, in Nissl material, mainly by a decrease in numbers of nerve cells and by an increased density of neuroglia cells (compare figs. 14 and 15). In those cases in

Fig. 11 Photograph of section through the forebrain of opossum (case 1), showing degenerated dorsal nucleus of lateral geniculate body (*d*), partially degenerated lateral nucleus of the thalamus (*l*), ventral nucleus of lateral geniculate body (*v*), and optic tract (*t*). Unoperated side at right. Cortical lesion between crosses (x-x). $\times 7$. Reduced silver method. 20μ section.

Fig. 12 Photograph of portion of degenerated dorsal nucleus of the lateral geniculate body shown in figure 11, at a higher magnification. Oriented as in figure 11. $\times 130$.

Fig. 13 Photograph of portion of normal dorsal nucleus shown in figure 11, at a higher magnification. Oriented as in figure 11. $\times 130$.



which large lesions have been produced, the affected parts of the dorsal nucleus of the ipsilateral geniculate body contain extremely few normal nerve cells, these appearing to have been replaced by neuroglia cells. The periphery of the degenerated zones in these cases, and most of the degenerated zones in the cases in which small lesions were produced, contain, however, many poorly stained nerve cells and many normal appearing nerve cells. Thus in no case is there a sharp transition between a completely degenerated zone and a normal one.

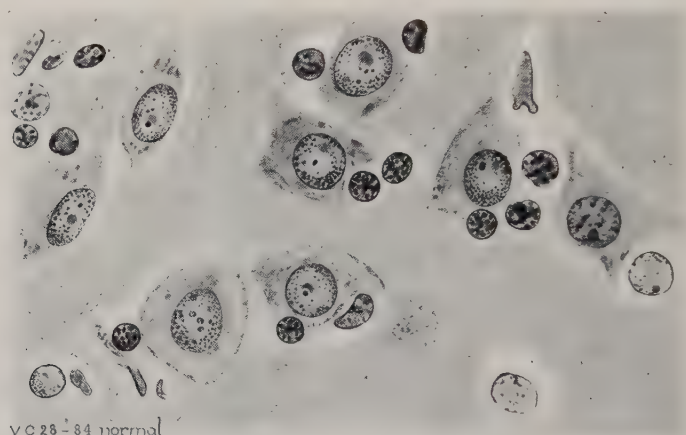


Fig. 14 Drawing of normal dorsal nucleus of the lateral geniculate body at a magnification of 1440. Section adjoining that shown in figures 11, 12 and 13. Toluidin blue. 20 μ section. Reduced to $\times 720$.

Furthermore, when areas, which upon superficial examination appear to be completely degenerated, are examined more carefully with higher powers of the microscope, a few scattered, normal appearing nerve cells can be found. When these were observed in the center of the area of degeneration in case 2, in which most of the striate area had been destroyed, and in which most of the dorsal nucleus of the lateral geniculate body appeared completely degenerated, it was thought that they might be cells which were degenerating at a slower rate. For this reason, case 1 was prepared, the animal being

allowed to live for 9 weeks after removal of most of the striate area, instead of $5\frac{1}{2}$ weeks, as in case 2. In Nissl material, the area of severest degeneration in case 1 was found to be similar in every respect to that in case 2. The scattered nerve cells were still apparent, several appearing in every 20μ section (fig. 15). In the sections of this brain which were impregnated with silver, there was obtained additional evidence that a few residual cells occur in areas of most complete degeneration. Such residual cells have been described in the cat by Monakow (1889) and Minkowski ('13), and in other mammals

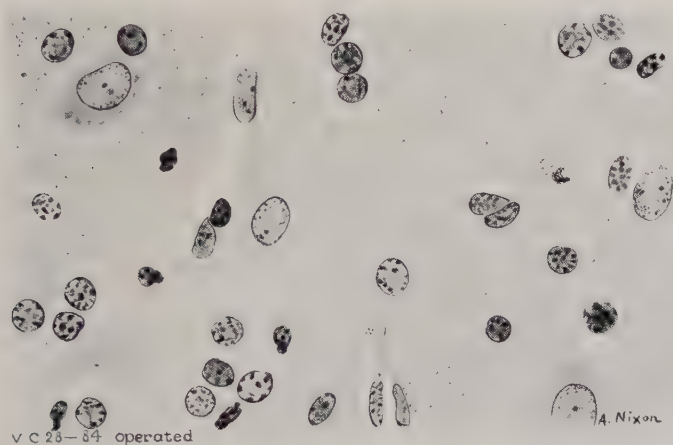


Fig. 15 Drawing of degenerated dorsal nucleus of the lateral geniculate body. Same section as that in figure 14. Toluidin blue. 20μ section. $\times 720$.

by de Vries ('10). They have been interpreted by these authors as being cells of Golgi's type II, but substantiating evidence for this belief has not been obtained as yet. Poliak ('32) has found no such residual cells in the lateral geniculate body of the monkey after removal of the striate area, nor has Lashley in the rat ('34 a).

The silver material shows, in addition, the extent of degeneration of fibers, which, of course, is not apparent in sections stained with toluidin blue. The degenerated dorsal nucleus of the lateral geniculate body, in contrast to the

normal contralateral nucleus, shows a marked atrophy of fibers of the optic radiation and pronounced degeneration of the interstitial material (neuropil) which appears coarsely granular, contains fewer fine fibers and is much lighter in color than that of the normal nucleus (figs. 11, 12, 13). This contrast in color is so great that, even with the naked eye, the degenerated nucleus can be easily differentiated, on the one hand, from the normal dorsal nucleus, and, on the other hand, from the ipsilateral ventral nucleus and the neighboring thalamic nuclei.

The pronounced change in appearance of the neuropil of the lateral geniculate body subsequent to destruction of the striate area is in decided contrast to the absence of such change in material fixed 10 weeks after unilateral sectioning of the optic nerve and impregnated with silver in a similar manner. The Rogers method, unfortunately, does not permit differentiation of the elements of the neuropil in sufficient detail to enable us to speak with certainty about the nature of the change which occurs in the atrophied nucleus. The altered appearance of the neuropil of the degenerated nucleus in silver material after striate area injury is due mainly, in all probability, to degeneration of terminals of optic tract fibers and of corticofugal fibers in addition to degeneration of the nerve cells and their dendritic processes. Sectioning of the optic nerve, on the other hand, results probably only in degeneration of optic tract fibers and their terminals. Apparently, this degeneration does not involve enough of the neuropil to make itself evident in Rogers material; this interpretation requires confirmation by methods which reveal in a specific manner the elements of the neuropil.

The lateral nucleus of the thalamus, which, as previously mentioned, has degenerated to some extent in cases 1 and 3 on the side of the lesion, shows on the normal side, in Rogers' material, a sparser distribution of cells than that found in the normal lateral geniculate body. Furthermore, the neuropil of the former is considerably less dense than that of the latter. The border between these two nuclei consequently

appears much sharper in silver preparations than in toluidin blue material. On the side of the lesion, the lateral nucleus shows a considerable loss of nerve cells in the Rogers material (case 1) and a distinct degeneration of the neuropil. This degeneration, however, is much less marked than that occurring in the lateral geniculate body.

DISCUSSION

There is lacking at the present time, unfortunately, a description of the detailed projection of the retina on the lateral geniculate body of the opossum. Nevertheless, in the absence of such a description, we may assume that this projection is comparable with that described in other mammals (Brouwer and Zeeman, '23, '25 and '26); Clark and Penman, '34; Lashley, '34, and others) if it is shown that the geniculocortical portion of the visual system of the opossum is comparable with theirs. The results of the experiments reported here lead us to believe that this is the case, that the anatomical projection of the lateral geniculate body on the striate cortex of the opossum is essentially similar to that described in placental mammals. That is, it seems clear from these experiments that definite parts of the dorsal nucleus of the lateral geniculate body of the opossum are anatomically connected by means of one neuron, and in a constant manner, with definite areas of the ipsilateral striate area, arranged in mosaic pattern, and with no other part of the neopallium.

However, these experiments further appear to indicate that the preciseness of the localization in the geniculocortical visual projection is by no means as great as that described, for example, in the monkey by Poliak ('33). He has shown that extremely small lesions in the striate area produce small, clearly defined, and completely degenerated zones in the lateral geniculate body; but in the opossum this is not the case, for only comparatively large lesions produce areas of complete atrophy, and even under these circumstances the peripheral parts of the atrophied zones are not completely degenerated. In addition, lesions covering an area

of less than about one-sixtieth of the total area of the striate cortex produce no discernible degeneration in the lateral geniculate body, although lesions in the monkey of much smaller relative size produce clear-cut degeneration. Unfortunately, minimal effective lesions have not been used in most of the previous experiments on mammals other than monkeys, so that it is difficult to say anything definite about the ultimate fineness of the projection in these animals. It is possible, as has been suggested by Poliak, that the margin of the zone of degeneration gives some information on the latter point, even where a relatively large lesion has been produced. If the border between a completely degenerated zone and a completely normal one is sharp, as is the case in the monkey, we can perhaps expect a finely detailed geniculocortical projection, whereas if the border is not sharp, but an incompletely degenerated transition zone intervenes, as in the opossum, the projection is probably less precise and of an overlap type. However, an irregular lesion in the cortex may produce a zone of degeneration with irregular and incompletely degenerated periphery, and, on the other hand, a large lesion, even when it has produced an area of atrophy which has sharp margins, does not tell us precisely how fine the projection really is.

It would be extremely interesting to be able to compare the preciseness of localization in the opossum with that in non-crepuscular marsupials. It appears from Lashley's report on the rat ('34 a), an essentially crepuscular mammal, that the localization in that creature is very precise. It should also be mentioned that the pattern of localization in that animal shows considerable differences from that found in the opossum, or in the rabbit (Putnam, '26), but resembles that of the latter more than that of the former.

Finally, it might be added that before this study was begun, the possibility suggested itself that in an extremely primitive mammalian brain, such as that of the opossum, the projection of the lateral geniculate body on the striate area of the cortex might be of a completely diffuse nature, and that only in

higher mammals does a localization of the projection develop within the striate area. On the other hand, the possibility also existed that localization within the visual cortex is initiated coincidentally with the origin in mammals of the optic radiation and of the striate area, and as an essential feature of the latter—in other words, that the development of a striate area in the neopallium signifies the development of visual pattern projection upon that cortex. This hypothesis is in accord with the more general suggestion of Herrick ('33 a) that the differentiation of cerebral cortex within the pallial field is effected under the influence of “the penetration of sensory projection fibers from the diencephalon into the pallial field” (p. 251; see also Herrick, '33). The evidence from the opossum brain, which is the lowliest mammalian brain readily available for experimentation, would seem to support both views in a certain measure. That is to say, a localized visual cortical projection is present in the opossum; but it is certainly not as highly differentiated as that of higher mammals. The advance in specialization has apparently involved an increase in the number of ultimate units of projection, and a refinement in the sharpness of the borders of the localized units, i.e., less overlap.

SUMMARY

1. Lesions in the striate area of the opossum produce definite and consistently localized foci of retrograde degeneration in the dorsal nucleus of the lateral geniculate body, indicating a mosaic arrangement of the elements of the visual cortical projection. The pattern of this arrangement has been mapped. It appears to differ considerably from the patterns described in the rat and in the rabbit.

2. Lesions involving an area no smaller than one-sixtieth of the total estimated size of the striate cortex produce recognizable, localized degeneration in the lateral geniculate body.

3. In no case is there a sharp transition between areas of most complete degeneration and normal zones in the lateral

geniculate body. Occasional residual cells persist in the zones of most complete degeneration. These are probably not cells which are degenerating at a slower rate.

4. Subsequent to removal of most of the striate cortex, silver material exhibits a pronounced change of the neuropil of the lateral geniculate body, strongly suggesting degeneration. No such change has been detected in silver material following unilateral sectioning of the optic nerve.

5. Degenerative changes in no other subcortical centers have been found after injury to the striate area.

6. Lesions in the peristriate area produce retrograde degeneration in the nucleus lateralis of the thalamus (nomenclature of Chu, '32).

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